New Jersey Department of Environmental Protection
Land Use Management
Water Monitoring and Standards
Post Office Box 409, Trenton
Water Monitoring Project

Leslie J. McGeorge, Administrator

REAPPRAISAL OF

SHELLFISH GROWING AREA DB3

THE DELAWARE BAY OFFSHORE

(CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL)

1998 - 2002

April 2004

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New Jersey Department of Environmental Protection
BRADLEY M. CAMPBELL
COMMISSIONER

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EXECUTIVE SUMMARY

The water quality data presented in this Reappraisal of Shellfish Growing Area DB3, the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal), were collected between October 1998 and September 2002. This shellfish growing area is a remote shellfish growing area and is sampled using the Adverse Pollution Condition (APC) strategy. According to NSSP sampling criteria, only 2 water samples are needed for each sampling station per year in remote shellfish growing areas. The water quality of this shellfish growing area was consistent with the *Approved* shellfish classification, as specified by the National Shellfish Sanitation Program (NSSP) criteria (USPHS, 1999 Revision).

INTRODUCTION

PURPOSE

This report is part of a series of studies having a dual purpose. The first and primary purpose is to comply with the guidelines of the National Shellfish Sanitation Program (NSSP) that are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying shellfish waters for the purpose of harvesting shellfish for human consumption. As such, they provide a critical link in protecting human health.

The second purpose is to provide input to the Integrated Water Quality Monitoring and Assessment Report, which is prepared pursuant to Sections 305(b) and 303(d) of the Federal Clean Water Act (P.L. 95-217). The information contained in the growing area reports is used for the 305b portion of the Integrated Report, which provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. The reports provide valuable information for the 305(b) portion of the Integrated Report, which describes the waters that are attaining state designated water uses and national clean water goals; the pollution problems identified in surface waters; and the actual or potential sources of pollution. Similarly, the reports utilize relevant information contained in the 305(b) portion of the Integrated Report, since the latter assessments are based on instream monitoring data (temperature, oxygen, pH, total and fecal coliform bacteria, nutrients, solids, ammonia and metals), land-use profiles, drainage basin characteristics and other pollution source information.

From the perspective of the Shellfish Classification Program, the reciprocal use of water quality information from reports represent two sides of the same coin: the growing area report focuses on the estuary itself, while the 305(b) portion of the report describes the watershed that drains to that estuary.

The Department participates in a cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA which emphasizes ongoing evaluation of issues associated with environmental regulation, including assessing impacts on waterbodies and measuring improvements in various indicators of environmental health. The shellfish growing area reports are intended to provide a brief assessment of the growing area, with particular emphasis on those factors that affect the quantity and quality of the shellfish resource. The shellfish growing area reports provide valuable information on the overall quality of the saline waters in the most downstream sections of each major watershed. In addition, the reports assess the quality of the biological resource and provide a reliable indicator of potential areas of concern and/or areas where additional information is needed to accurately assess watershed dynamics.

HISTORY

As a brief history, the NSSP developed from public health principles and program controls formulated at the original conference on shellfish sanitation called by the Surgeon General of the United States Public Health Service in 1925. This conference was called after oysters were implicated in causing over 1500 cases of typhoid fever and 150 deaths in 1924. The tripartite cooperative program (federal, state and shellfish industry) has updated the program procedures and guidelines through workshops held periodically until 1977. Because of concern by many states that the NSSP guidelines were not being enforced uniformly, a delegation of state shellfish officials from 22 states met in 1982 in Annapolis, Maryland, and formed the ISSC. The first annual meeting was held in 1983 and continues to meet annually at various locations throughout the United States.

The NSSP *Guide for the Control of Molluscan Shellfish* sets forth the principles and requirements for the sanitary control of shellfish produced and shipped in interstate commerce in the United States. It provides the basis used by the Federal Food and Drug Administration (FDA) in evaluating state shellfish sanitation programs. The five major points on which the state is evaluated by the FDA include:

1. The classification of all actual and potential shellfish growing areas as to their suitability for shellfish harvesting.
2. The control of the harvesting of shellfish from areas that are classified as restricted, prohibited or otherwise closed.
3. The regulation and supervision of shellfish resource recovery programs.
4. The ability to restrict the harvest of shellfish from areas in a public health emergency, and
5. Prevention of the sale, shipment or possession of shellfish that cannot be identified as being produced in accordance with the NSSP and have the ability to condemn, seize or embargo such shellfish.

FUNCTIONAL AUTHORITY

The authority to carry out these functions is divided between the Department of Environmental Protection (DEP), the Department of Health and Senior Services and the Department of Law and Public Safety. The Bureau of Marine Water Monitoring (BMWM), under the authority of N.J.S.A. 58:24, classifies the shellfish growing waters and administers the special resource recovery programs. Regulations delineating the growing areas are promulgated at N.J.A.C. 7:12 and are revised annually. Special Permit rules are also found at N.J.A.C. 7:12 and are revised as necessary.

The Bureau of Shellfisheries, in the Division of Fish and Wildlife, issues harvesting licenses and leases for shellfish grounds under the Authority of N.J.S.A. 50:2 and N.J.A.C. 7:25. This bureau, in conjunction with the BMWM, administers the Hard Clam Relay Program.

The Bureau of Law Enforcement in the DEP (Division of Fish and Wildlife) and the Division of State Police in the Department of Law and Public Safety enforce the provisions of the statutes and rules mentioned above.

The Department of Health and Senior Services is responsible for the certifications of wholesale shellfish establishments and in conjunction with the BMWM, administers the depuration program.

The division of authority between the three agencies can be seen in Figure 1.

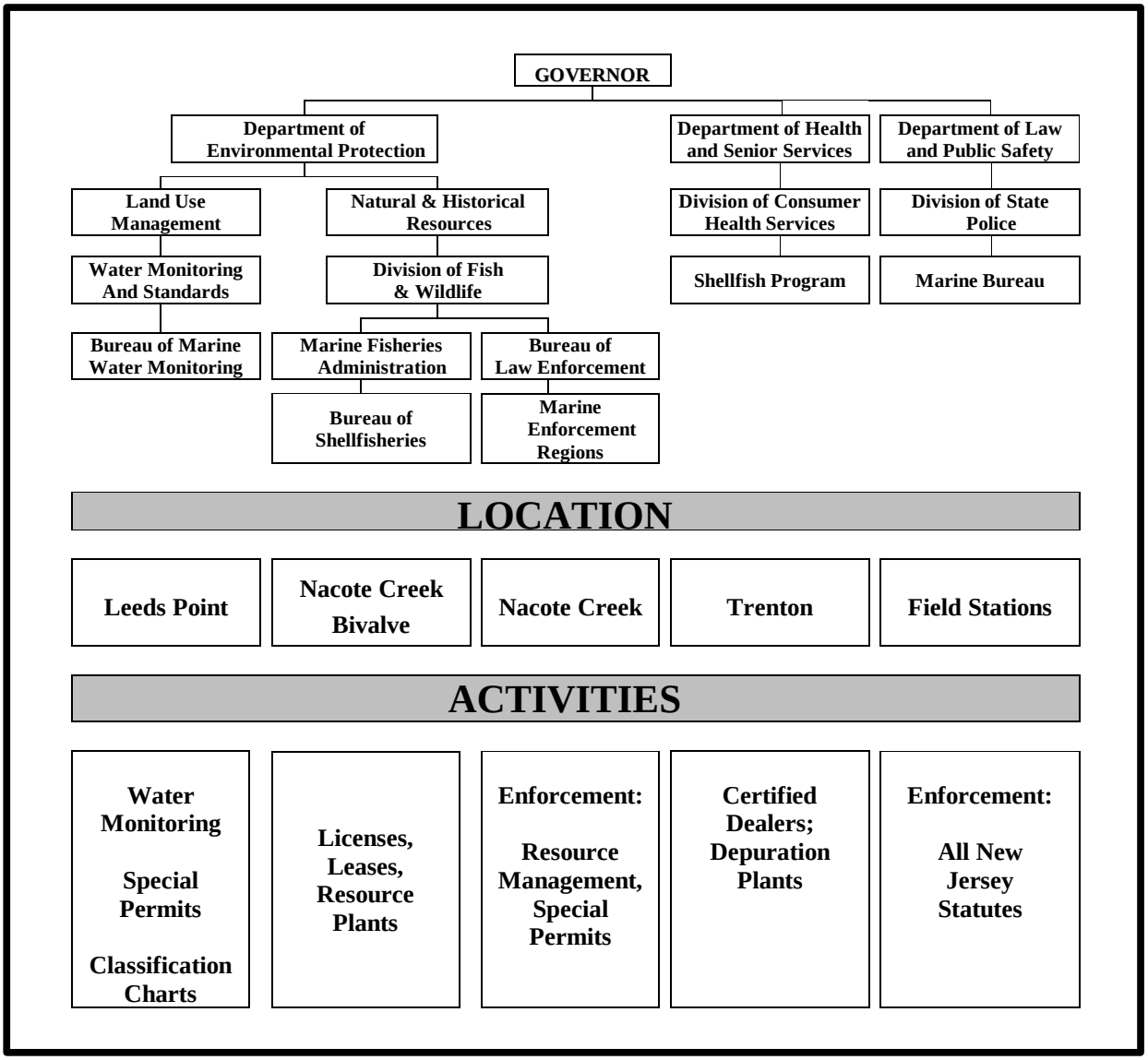

FIGURE 1: STATE OF NEW JERSEY SHELLFISH AGENCIES

IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

Emphasis is placed on the sanitary control of shellfish because of the direct relationship between pollution of shellfish growing areas and the transmission of diseases to humans. Shellfish borne infectious diseases are generally transmitted via a fecal-oral route. The pathway is complex and quite circuitous. The cycle usually begins with fecal contamination of the shellfish growing waters. Sources of such contamination are many and varied. Contamination reaches the waterways via storm water runoff from urban and agricultural areas and from direct discharges such as wastewater treatment facilities.

Clams, oysters and mussels pump large quantities of water through their bodies

during the normal feeding process. During this process the shellfish also concentrate microorganisms, which may include pathogenic microbes, and toxic heavy metals/chemicals. It is imperative that a system is in place to reduce the human health risk of consuming shellfish from areas of contamination.

Accurate classifications of shellfish growing areas are completed through a comprehensive sanitary survey. The principal components of the sanitary survey report include:

1. An evaluation of all actual and potential sources of pollution,
2. An evaluation of the hydrology of the area and
3. An assessment of water quality. Complete intensive Sanitary Surveys are conducted every 12 years with interim narrative evaluations (Reappraisals) completed on a three-year basis. If major changes to the shoreline or bacterial quality occur, then the intensive report (Sanitary Survey) is initiated prior to its l2 year schedule. Also, if only a section of a growing area is either upgraded or downgraded from its current shellfish classification, a partial intensive report (Partial Sanitary Survey) is conducted for that shellfish growing area. Annual Reviews are written on a yearly basis for each shellfish growing area.

The following narrative constitutes this bureau's assessment of the above mentioned components and determines the current classification of the shellfish growing waters of Shellfish Growing Area DB3, The Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal).

GROWING AREA PROFILE

LOCATION AND DESCRIPTION

Shellfish Growing Area DB3: The Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) is a remote shellfish growing area located in the southwestern part of New Jersey (USDI-GS, 1972- Cape May, USDI-GS, 1977-Fortescue, USDI-GS, 1977-Heislerville, USDI-GS, 1977-Port Norris, USDI-GS, 1977-Rio Grande). The eastern edge of this shellfish growing area is about 1.7 miles west of the shoreline bordering the coast of Lower Township and Middle Township in Cape May County and about 2.5 miles west of the shoreline bordering the coast of Dennis Township in Cape May County. The northern edge of this shellfish growing area is located 1.2 miles south of the shoreline bordering the coast of Maurice River Township and only about 183 yards from the southern tip of Egg Island Point in Downe Township, Cumberland County. The western edge of this shellfish growing area is located at the border between New Jersey and Delaware, which is on a line extending from a point about 7.5 miles west of Egg Island Point and going southeast to a point about 7.3 miles west of Cape May Point (see Figure 2). This remote shellfish growing area does not border on any shorelines. The primary shellfish classification of this growing area is *Approved* and the approximate size of this shellfish growing area is 135,345 acres.

The municipalities onshore of this remote shellfish growing area include Cape May Point Boro, Lower Township, Middle Township, and Dennis Township to the east in Cape May County, and Maurice River Township, Commercial Township, Downe Township, and Lawrence Township to the north in Cumberland County. The locations of these municipalities are shown in Figure 2, and the population statistics for the surrounding municipalities are shown in Table 1.

In Cumberland County, the Delaware River drains into this shellfish growing area. This area can be found on Chart 9 and Chart 10 of the “2002 State of New Jersey – Shellfish Growing Water Classification Charts” (NJDEP, 2002). Figure 3 shows the current classification of this shellfish growing area.

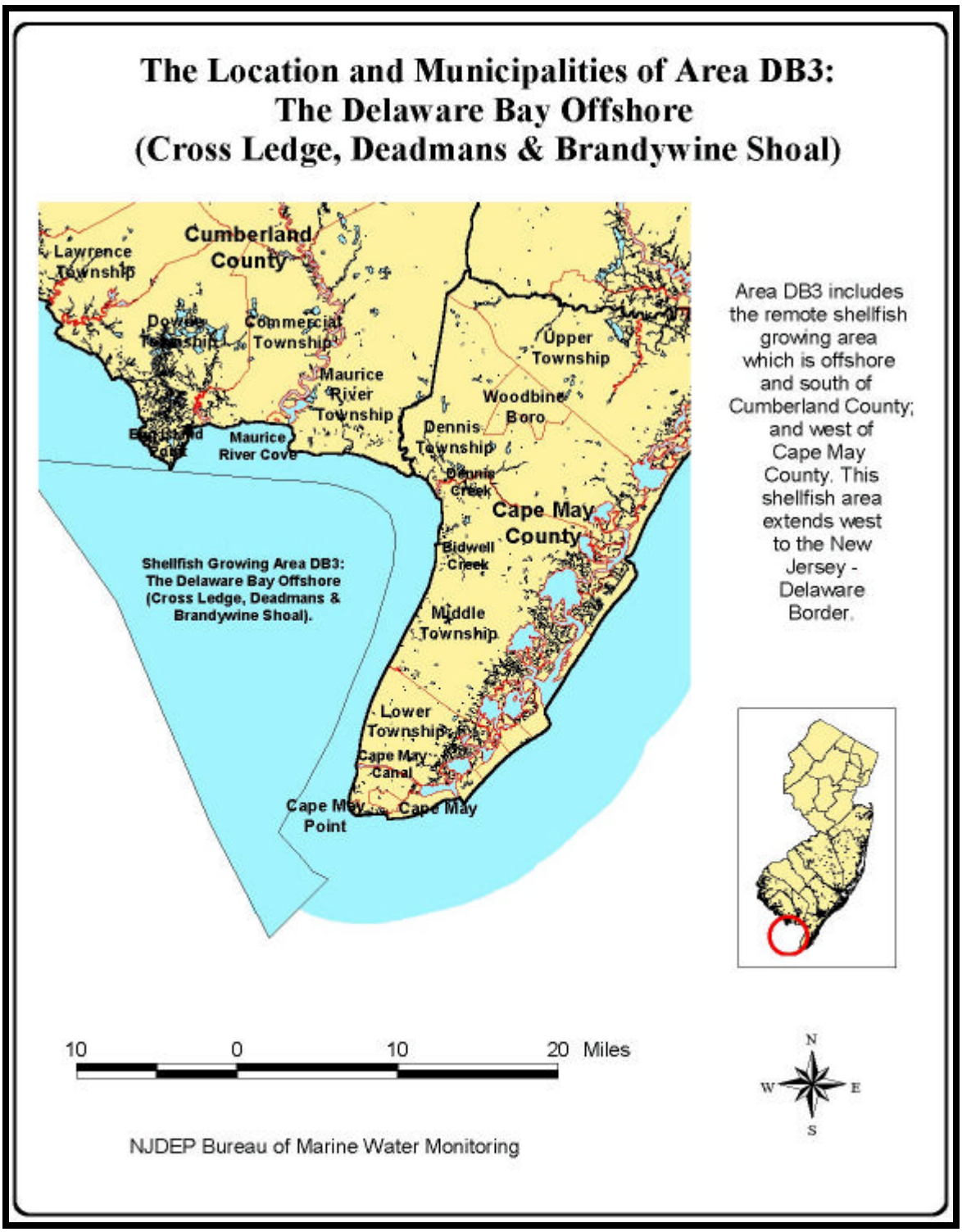

FIGURE 2: LOCATION AND MUNICIPALITIES OF SHELLFISH GROWING AREA DB3 – DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

TABLE 1: POPULATION STATISTICS FOR MUNICIPALITIES SURROUNDING SHELLFISH GROWING AREA DB3– DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL) (NJ DEPARTMENT OF LABOR, 2001)**.**

Community	Area (sq. mi.)	Population (2000 Census)	Population Density
Cape May Point Boro (Cape May County)	0.32	241	735
Lower Township (Cape May County)	31.21	22,945	735
Middle Township (Cape May County)	82.80	16,405	198
Dennis Township (Cape May County)	64.21	6,492	101
Maurice River Township (Cumberland County)	93.52	6,928	74
Commercial Township (Cumberland County)	32.59	5,259	161
Downe Township (Cumberland County)	53.19	1,631	31
Lawrence Township (Cumberland County)	37.51	2,721	72

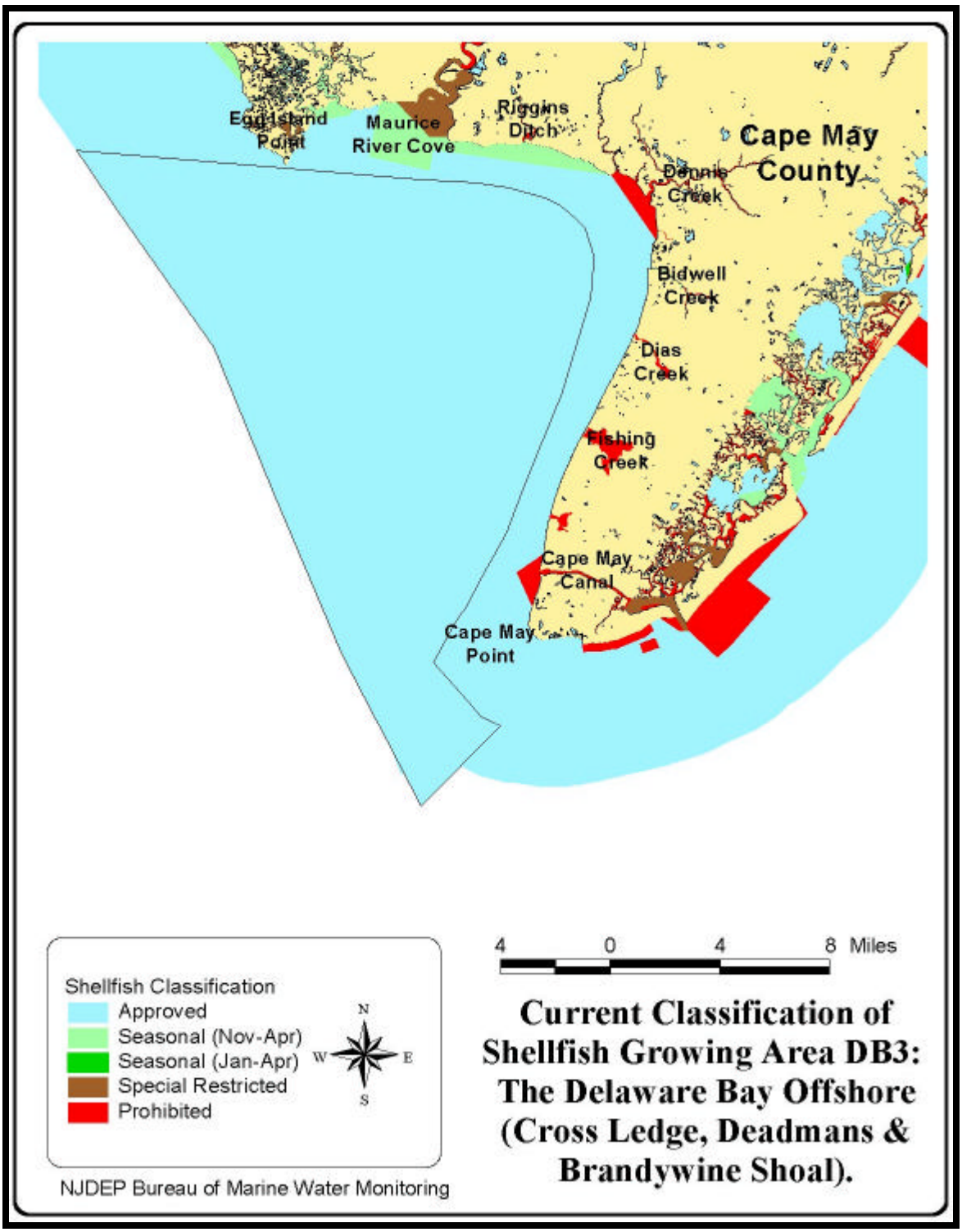

FIGURE 3: CURRENT CLASSIFICATION OF SHELLFISH GROWING AREA DB3 – DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

HISTORY OF GROWING AREA CLASSIFICATION

The Delaware Bay Offshore area has historically been an area with a medium abundance of eastern oysters (*Crassostrea virginica*) and a low abundance of hard clams (*Mercenaria Mercenaria*) (Morris, 1975, Gosner 1978). The shellfish waters of this area are primarily classified as *Approved* (NJDEP, 2002). Since 1992, this shellfish growing area has been classified and sampled as a remote area. According to the NSSP *Guide for the Control of Molluscan Shellfish,* a growing area may be placed in the remote status if 1) a sanitary survey determines that the area has no human habitation, and is not impacted by any actual or potential pollution sources, and 2) the area is in water that is classified as *Approved* (USPHS, 1999 Revision). Shellfish Growing Area DB3: the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) meets both of these criteria.

In the Reappraisal of the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) for 1998, data were evaluated from October 1995 to September 1998 and all of the sampling stations met the *Approved* criteria for water quality. No changes were proposed for the shellfish classification or sampling strategy for this shellfish growing area (Watkins, 1998). An Annual Review of this area was submitted in March 2003, using water data from 1998 to 2002, and all of the sampling stations in this shellfish growing area met the *Approved* shellfish classification criteria. The last Sanitary Survey for this area was written in 1992, and the next Sanitary Survey is due in 2004.

METHODS

Water sampling was performed in accordance with the Field Procedures Manual (NJDEP, 1992).

Approximately 192 water samples were collected for total and fecal coliform bacteria between 1998 and 2002 and analyzed by the three-tube MPN method according to APHA (1970). Figure 7 shows the shellfish growing water quality monitoring stations in the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal). Approximately 12 stations are monitored during each year in Marine Water Sampling Assignment Area 376.

Water quality sampling, shoreline and watershed surveys were conducted in accordance with the NSSP *Guide for the Control of Molluscan Shellfish* (USPHS, 1999 Revision).

Data management and analysis was accomplished using database applications developed for the Bureau. Mapping of pollution data was performed with the Geographic Information System (GIS: ARCVIEW®).

BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS

The water quality of each growing area must be evaluated before an area can be classified as *Approved, Seasonally Approved (November to April), Seasonally Approved (January to April), Special Restricted,* or *Prohibited.* Criteria for bacterial acceptability of shellfish growing waters are provided in NSSP *Guide for the Control of Molluscan Shellfish* (USPHS, 1999 Revision).

SAMPLING STRATEGY

The State Shellfish Control Authority has the option of choosing one of two water monitoring sampling strategies for each growing area.

The Adverse Pollution Condition (APC) strategy requires that a minimum of five samples be collected each year under conditions that have historically resulted in elevated coliforms in the particular growing area. The results must be evaluated by adding the individual station sample results to the preexisting bacteriological sampling results to constitute a data set of at least 15 samples for each station. The adverse pollution conditions usually are related to tide, and rainfall, but could be from a point source of pollution or variation could occur during a specific time of the year (Connell, 1991).

The Systematic Random Sampling (SRS) strategy requires that a random sampling plan be in place before field sampling begins. This strategy can only be used in areas that are not affected by point sources of contamination. A minimum of six samples per station are to be collected each year and added to the database to obtain a sample size of 30 for statistical analysis.

The Delaware Bay offshore remote area (Cross Ledge, Deadmans & Brandywine Shoal) is sampled under the Adverse Pollution Condition strategy year-round for all sampling stations in this area (Assignment Area 376).

NSSP CRITERIA

Each shellfish producing state is directed to adopt either the total coliform criterion, or the fecal coliform criterion. While New Jersey bases its growing water classifications on the total coliform criterion, it does make corresponding fecal coliform determinations for each sampling station. These data are viewed as adjunct information and are not directly used for classification.

The criteria were developed to ensure that shellfish harvested from the designated waters would be free of pathogenic (disease-producing) bacteria.

Each classification criterion is composed of a measure of the statistical 'central tendency' (geometric mean) and the relative variability of the data set. For the Adverse Pollution Condition sampling strategy, variability is expressed as the percentage that exceeds the variability criteria (see Table 2). For the Systematic Random Sampling Strategy, variability is expressed as the 90th percentile (see Table 3).

Areas to be *Approved* under the Seasonal classification must be sampled and meet the criterion during the time of the year that it is approved for the harvest of shellfish.

TABLE 2: CRITERIA FOR ADVERSE POLLUTION CONDITION SAMPLING STRATEGY

	Total Coliform Criteria		**Fecal Coliform Criteria**	
	Geometric mean (MPN/100 mL)	**No more than 10% of sample can exceed (MPN/100 mL)**	**Geometric mean (MPN/100 mL)**	**No more than 10% of sample can exceed (MPN/100 mL)**
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

TABLE 3: CRITERIA FOR SYSTEMATIC RANDOM SAMPLING STRATEGY

	Total Coliform Criteria		**Fecal Coliform Criteria**	
	Geometric mean (MPN/100 mL)	**Estimated 90th percentile (MPN/100 mL)**	**Geometric mean (MPN/100 mL)**	**Estimated 90th percentile (MPN/100 mL)**
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

SHORELINE SURVEY

CHANGES SINCE LAST SURVEY

Shellfish Growing Area DB3: the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) is a remote area, which is completely surrounded by water. It borders Shellfish Growing Area DB2 (The Delaware Bay - Cape Shore) and Shellfish Growing Area DB1 (The Delaware Bay from Maurice River Cove to Artificial Island). There is no current evidence that the direct and indirect discharges from Shellfish Growing Areas DB1 and DB2 affect the water quality of this shellfish growing area.

LAND USE

The major land use patterns for the municipalities to the north and east of this remote offshore shellfish growing area are mainly wetland areas, agricultural areas, and forest areas, with some urban areas interspersed between them (see Figure 4). The urban areas are mainly located in clusters to the southeast, east, and north of this remote shellfish growing area, but this growing area does not border on any of these urban areas. There is no current evidence that the direct and indirect discharges from these surrounding urban areas affects the water quality of this remote offshore shellfish growing area.

The wetlands onshore and surrounding this remote shellfish growing area also contain the Cape May National Wildlife Refuge to the east, the Dennis Creek Wildlife Management Area to the northeast, and Corsons Wildlife Management Area, Heislerville Wildlife Management Area, Egg Island Berrytown Wildlife Management Area, and Fortescue Wildlife Management Area to the north. Figure 4 shows the land use patterns for the surrounding shoreline of this area. There are no storm water outfalls or marinas draining into this remote offshore shellfish growing area.

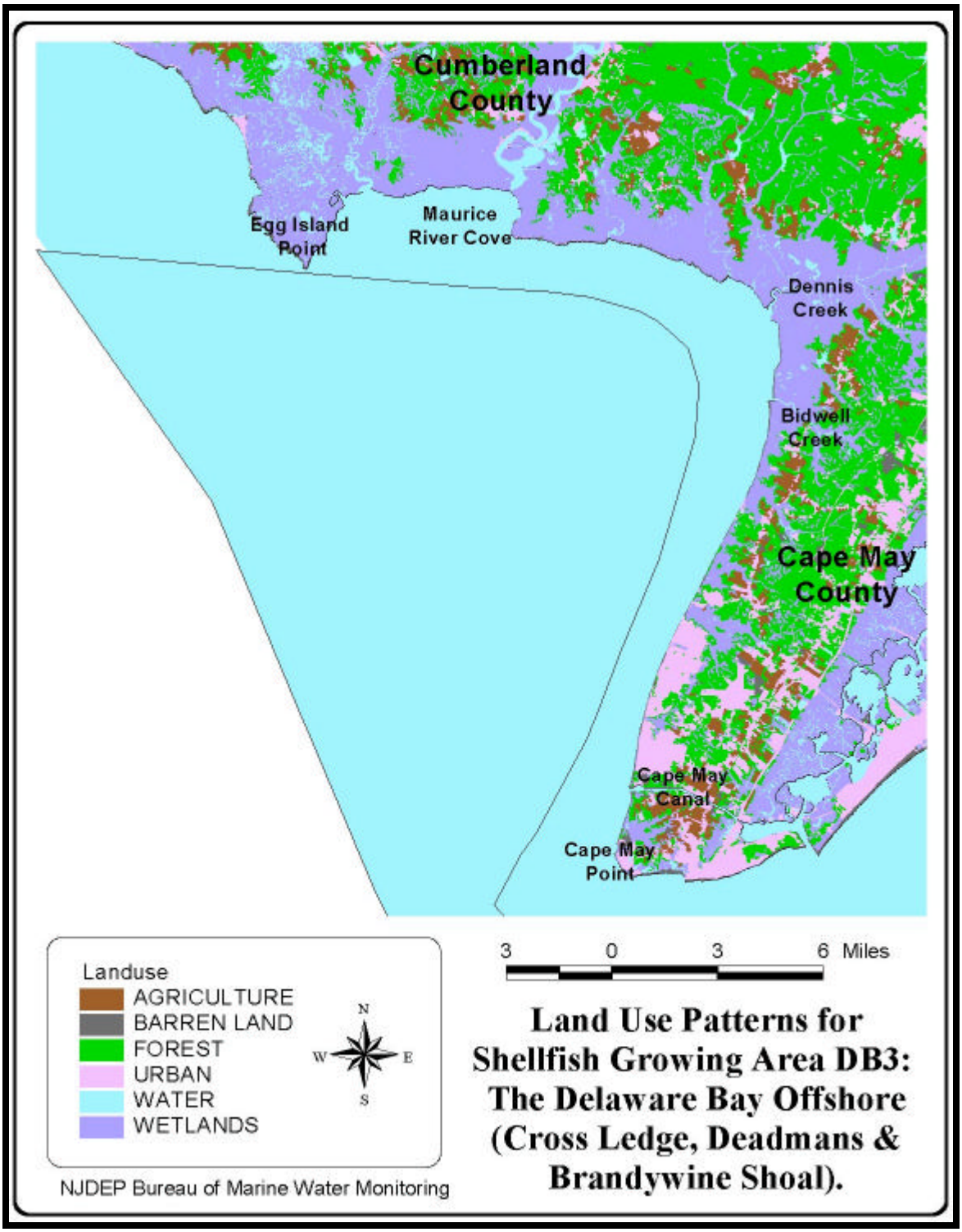

FIGURE 4: LAND USE PATTERNS FOR SHELLFISH GROWING AREA DB3 – DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

EVALUATION OF BIOLOGICAL RESOURCES

The ports of Cape May County and Atlantic County provide at least half of the State of New Jersey's seafood value, which is a significant contribution to the economy and employment of southern New Jersey. In 1998, New Jersey harvested about 196 million pounds of seafood products, which were valued at over $90 million (Flemlin and Tweed, 2000).

This growing area has a wide diversity of biological resources (see Figure 5). Hard clams (*Mercenaria Mercenaria*) exist in low abundance and are privately and commercially harvested (Morris, 1975, Gosner, 1978). In New Jersey for 1999, the shellfish landings for hard clams were 1,880,327 pounds of meat for an exvessel value of $7,363,453 (NJDEP, 2001). The eastern oyster (*Crassostrea virginica*) exists in medium abundance in the Delaware Bay, and has a long history of its commercial and economic importance in the Delaware Estuary (Morris, 1975, Gosner, 1978, Matassino, et al, 2002). In New Jersey for 1999, the shellfish landings for oysters were 411,377 pounds of meat for an exvessel value of $1,571,711 (NJDEP, 2001).

The cities of Port Norris and Bivalve, along the Maurice River in Cumberland County, were once known as the hub of the Delaware Bay oyster industry, and Bivalve was once recognized to be the oyster capitol of the world for its production and processing industries. Its oyster industry processed and delivered thousands of pounds of oysters to markets all over the eastern coast of the United States (Flemlin and Tweed, 2000, Matassino, et al, 2002).

The population of oysters in the Delaware Bay has fluctuated widely. In the early 1900's, annual oyster landings were from one million to two million bushels. However, in the 1950's, the oyster population was reduced dramatically by the disease MSX, which is caused by the parasite *Haplosporidium nelsoni*. Only 49,000 bushels of oysters were harvested in the Delaware Bay in 1960. There was a gradual increase in the numbers of oysters harvested in the late 1960's and early 1970's. Then, in 1990, a new disease named Dermo was found to be spreading among the oyster population on the eastern side of the Delaware Bay and it caused heavy losses of both planted and seeded oysters. Dermo is caused by the parasite *Perkinsus marinus*. In 1988, juvenile oyster disease (JOD) also became a serious problem for oyster nurseries in the northeastern Atlantic region. The causative agent for JOD is unknown.

The Haskins Shellfish Research Laboratory of Rutgers University has attempted to develop disease resistant strains of oysters that show a resistance to MSX. Their long-term oyster-breeding program has managed to genetically produce a disease resistant strain of oysters for MSX, and they have also managed to genetically produce an oyster with some resistance to Dermo. These disease resistant oysters are the

main production line for the Atlantic Cape Fisheries oyster farm in Cape May (Guo and Kraeuter, 2000).

The bacteria *Vibrio parahaemolyticus* also causes illness from eating raw oysters, clams, and mussels infected with the bacteria. An outbreak of *Vibrio parahaemolyticus* entertitus occurred in July 2002 from oysters harvested in the Delaware Bay, and as a result, portions of the Delaware Bay were closed for shellfish harvesting.

The Delaware Bay also contains the world's largest population of horseshoe crabs (*Limulus polyphemus*). However, since horseshoe crabs are used as bait for catching eels and conch, and their natural habitat is gradually being lost to development and shoreline retreat, the population of horseshoe crabs has been declining. Migrating shorebirds also feed on the eggs of nesting horseshoe crabs, which also contributes to their decline in population numbers (Matassino, et al., 2002).

Striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) are also an important biological resource in the Delaware Bay and Delaware River (Matassino, et al., 2002). Both of these species of fish are commercially and recreationally harvested in the waters of this shellfish growing area, since this area is also utilized for fishing and boating. In 1991, the striped bass was classified as a gamefish in New Jersey, and this status prevents the commercial harvest or sale of this first coastal saltwater species designated as such in New Jersey (Bochenek, 2000).

The Delaware Bay Estuary is also located along the Atlantic Flyway, an important migratory corridor for wildlife populations of shorebirds. This area is considered to be one of the largest stopover locations along the Atlantic Flyway, with an estimated 425,000 to 1,000,000 migratory shorebirds converging and feeding in the Delaware Bay Estuary. Red Knot, Dunlin, Ruddy Turnstone, Sanderling, Semi-Palmated Sandpiper, and other species of shorebirds use the Delaware Bay Estuary as an important resting and feeding area, and they are known to consume large quantities of horseshoe crab eggs (certain species of shorebirds can and will eat thousands of horseshoe crab eggs in a single day) (Matassino, et al., 2002).

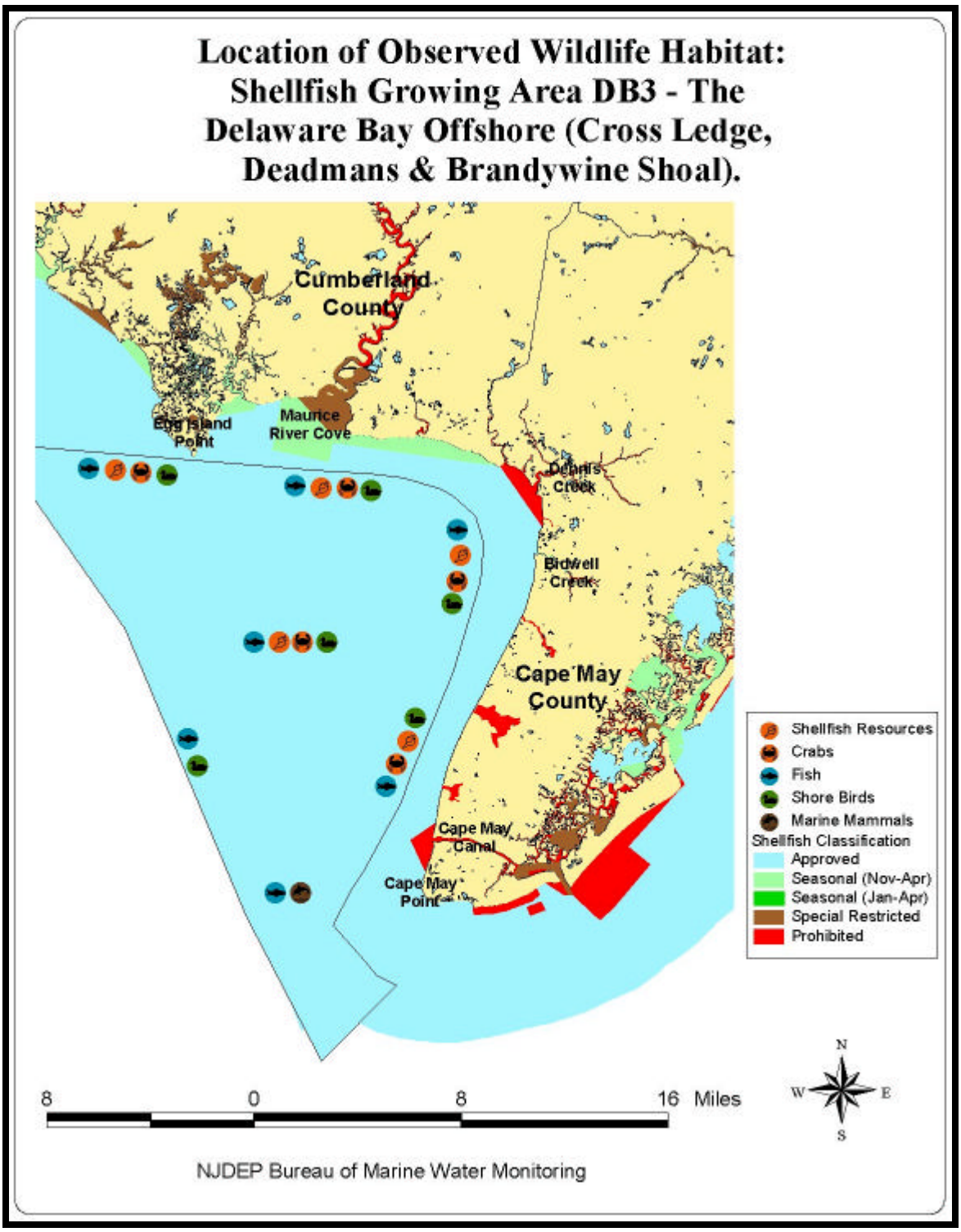

FIGURE 5: SHELLFISH RESOURCES FOR SHELLFISH GROWING AREA DB3 – DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

HYDROLOGY AND METEOROLOGY

PATTERNS OF PRECIPITATION

Precipitation patterns in the coastal areas of New Jersey are typical of the Mid-Atlantic coastal region (see Table 4). Typical summer storms are localized storms associated with thunderstorms. Winter storms are frequently associated with northeasters. Hurricanes can occur during the summer and early fall.

TABLE 4: AVERAGE MID-ATLANTIC STORM EVENT INFORMATION. SOURCES: USEPA; US DEPARTMENT OF COMMERCE

Annual Average Number of Storms	60
Average Storm Event Duration	10 hours
Average Storm Event Intensity	0.08 – 0.09 inches/hour
Average Storm Event Volume	0.65 inches

Although the average storm event lasts approximately 10 hours, with an accumulation of 0.65 inches, it is not unusual for an individual storm volume to be 2 – 3 inches. Note the data below show the 2-year return 6-hour storm event to be between two (2) and three (3) inches, while the 2-year 24-hour return volume varies between three (3) and four (4) inches (see Table 5). Storm volumes greater than approximately 3.5 – 4.0 inches are much less frequent.

TABLE 5: STORM EVENT VOLUME FOR 2-YEAR STORM EVENT RECURRENCE (SOURCE: USGS**)**

Location	2-Year, 1-Hour Rainfall	2-Year, 6-Hour Rainfall	2-Year, 24-Hour Rainfall
Millville	1.33	2.33	3.02
Cape May	1.33	2.41	3.10
Atlantic City	1.47	2.67	3.65
Long Branch	1.55	3.02	4.15
Newark	1.21	2.34	3.25
Sandy Hook	1.37	2.73	3.68

The duration and volume of storm events can also be depicted as frequency histograms. This graphical depiction (shown below in Figure 6 for Shellfish Growing Area DB3 with measurements taken at the NOAA Millville Municipal Airport station in Millville, NJ, the Cape May Station, and the Atlantic City International Airport Station in Pomona, NJ for the time period from 1998 to 2002) provides insight into the frequency of cumulative precipitation of a given size.

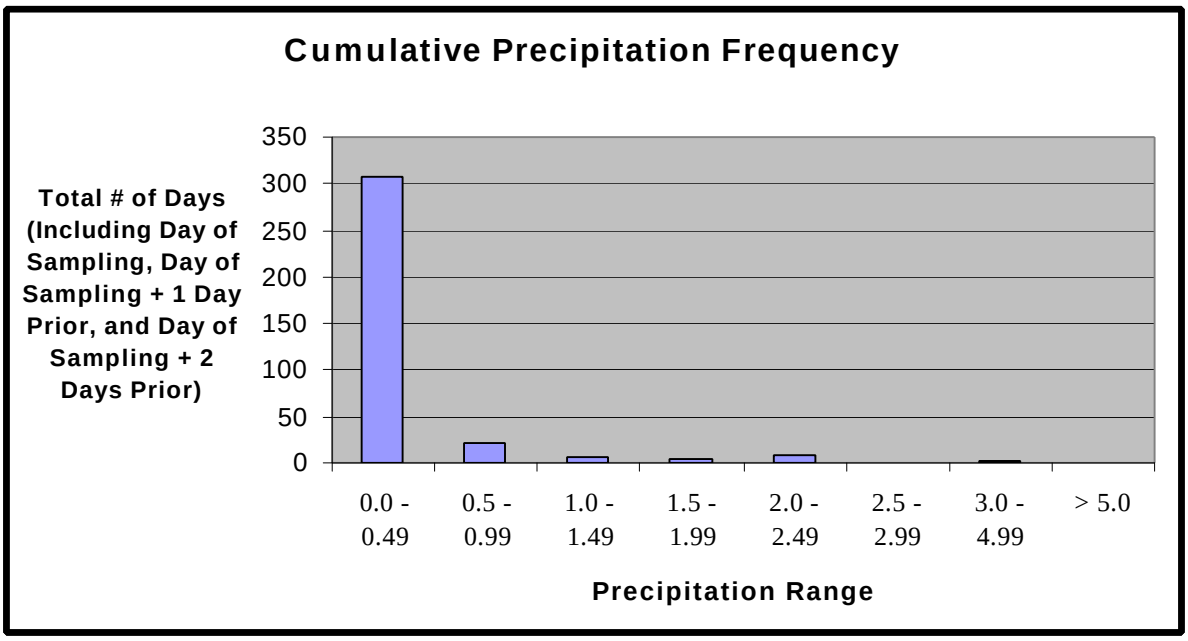

FIGURE 6: STORM EVENT FREQUENCY HISTOGRAM (1998-2002) (SOURCE: NOAA CLIMATIC DATA)

HYDROLOGY

Shellfish Growing Area DB3 – the Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) typically has depths ranging from 3 feet to 39 feet (MLW) from Cape May Channel to Cross Ledge. The mean range of tide is 4.3 feet for the shoreline southeast of this area that extends from Cape May Point in Cape May County to Cox Hall Creek in Lower Township, Cape May County. The mean range of tide is 5.1 feet for the shoreline east of this area that extends from Cox Hall Creek in Lower Township, Cape May County, to Reeds Beach in Middle Township, Cape May County. The mean range of tide is 5.6 feet for the shoreline northeast of this area that extends from Reeds Beach in Middle Township, Cape May County, to Thompsons Beach in Maurice River Township, Cumberland County. The mean range of tide is 5.7 feet for the shoreline north of this area

that extends from Thompsons Beach in Maurice River Township, Cumberland County, to Oranoaken Creek in Downe Township, Cumberland County. The mean range of tide is 5.9 feet for the shoreline northwest of this area that extends from Oranoaken Creek in Downe Township, Cumberland County, to Fortescue Creek in Downe Township, Cumberland County. Table 6 shows the mean range of tides for the shorelines surrounding this shellfish growing area. The tidal cycle is semidiurnal, with two high tides and two low tides in a 24 hour, 50 minute period. The tides around the Atlantic Ocean occur twice a day (two high and two low) and have essentially the same range, or vertical distance from high to low water (Ingmanson and Wallace, 1989). The Delaware River drains into this shellfish growing area and tidal flushing occurs through the Cape May Channel (USDI-GS, 1977-Fortescue, USDI-GS, 1972-Cape May).

This shellfish growing area was sampled with no preference for ebb or flood tide. Ebb and flood tides describe the horizontal motions associated with the fall and rise of the tide in restricted regions along the coast. Tidal currents can affect the water quality of a shellfish growing area, because hydrographic and meteorological characteristics, such as tidal amplitude and type, water circulation patterns, depth, salinity, stratification characteristics, rainfall patterns and intensity, and prevailing winds, may affect the distribution of pollutants in a specific area (Ingmanson and Wallace, 1989). This is why an evaluation of pollution sources and hydrographic characteristics are used to evaluate the water quality in a shellfish growing area.

Precipitation inputs to this area for the period 1998 through 2002 are shown in Table 7, and the Storm Event Frequency Histogram for this area from 1998 through 2002 is shown in Figure 6. There have been no significant changes in hydrology since 1998.

The primary weather station for this area is the Millville Municipal Airport in Millville, NJ. The secondary weather stations for this area are the Cape May Station and the Atlantic City International Airport Station in Pomona, NJ. The secondary station data are used when data from the primary station are incomplete.

TABLE 6: TABLE OF MEAN RANGE OF TIDES FOR THE SHORELINES SURROUNDING AREA DB3: DELAWARE BAY OFFSHORE (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

Location:	**Township:**	**County:**	**Mean Range of Tide (MLW)**
From: Cape May Point	Cape May Point	Cape May	4.3 feet
To: Cox Hall Creek	Lower Township	Cape May	
From: Cox Hall Creek	Lower Township	Cape May	5.1 feet
To: Reeds Beach	Middle Township	Cape May	
From: Reeds Beach	Middle Township	Cape May	5.6 feet
To: Thompsons Beach	Maurice River Township	Cumberland	
From: Thompsons Beach	Maurice River Township	Cumberland	5.7 feet
To: Oranoaken Creek	Downe Township	Cumberland	
From: Oranoaken Creek	Downe Township	Cumberland	5.9 feet
To: Fortescue Creek	Downe Township	Cumberland	

TABLE 7: CLIMATOLOGICAL DATA

Rainfall Recorded at NOAA's Millville Airport Station, the Cape May Station, and the Atlantic City Airport Station

Sampling Date	Precipitation in Inches			NOAA WSO Number *
	Day of Sampling	1 day prior	2 days prior	
04/07/99	0.000	0.000	0.005	5581
04/07/99	0.000	0.000	0.000	1351
05/05/99	0.000	0.000	0.005	5581
06/22/99	0.000	0.140	0.850	1351
06/22/99	0.000	0.300	1.980	5581
07/06/99	0.000	0.000	0.000	5581
07/21/99	0.000	0.180	0.180	5581
07/27/99	0.000	0.000	0.000	5581
07/27/99	0.000	0.020	0.020	1351
08/05/99	0.000	0.000	0.000	5581
09/13/99	0.000	0.000	0.000	5581
10/07/99	0.000	0.000	0.000	5581
10/20/99	1.770	1.770	2.260	1351
10/20/99	0.950	0.950	1.000	5581
05/31/00	0.000	0.000	0.010	5581
06/14/00	0.020	0.020	0.030	5581
06/14/00	0.010	0.030	1.010	1351
06/28/00	2.000	2.020	2.020	311
07/24/00	0.020	0.020	0.270	5581
07/24/00	0.030	0.030	0.030	1351
07/27/00	0.300	0.930	1.090	5581
08/11/00	0.000	0.000	0.000	1351
08/11/00	0.000	0.000	0.030	5581
09/18/00	0.000	0.000	0.000	311
09/22/00	0.000	0.000	0.000	1351
09/22/00	0.000	0.000	0.005	311
10/03/00	0.000	0.000	0.000	311
11/28/00	0.020	0.360	1.910	5581
11/28/00	0.000	0.000	0.230	1351
12/07/00	0.005	0.005	0.005	5581
01/29/01	0.000	0.010	0.015	5581
03/27/01	0.000	0.110	0.110	5581
04/02/01	0.020	0.020	0.030	5581
04/09/01	0.160	0.300	0.300	5581
04/17/01	0.110	0.130	0.400	5581
05/01/01	0.000	0.000	0.000	5581
05/03/01	0.000	0.000	0.000	1351
05/03/01	0.000	0.000	0.000	5581
06/27/01	0.000	0.000	0.000	1351

Sampling Date	Precipitation in Inches			NOAA WSO Number *
	Day of Sampling	1 day prior	2 days prior	
06/27/01	0.000	0.000	0.000	5581
07/27/01	0.000	0.380	0.380	5581

Sampling Date	Precipitation in Inches			NOAA WSO Number *
	Day of Sampling	1 day prior	2 days prior	
08/02/01	0.000	0.000	0.000	1351
08/02/01	0.000	0.000	0.000	5581
09/24/01	0.260	0.260	0.290	1351
09/24/01	0.060	0.060	0.060	5581
10/22/01	0.000	0.000	0.000	5581
11/27/01	0.000	0.005	0.865	5581
12/19/01	0.000	0.030	0.080	5581
01/09/02	0.005	0.005	0.010	5581
02/06/02	0.000	0.000	0.010	5581
04/12/02	0.090	0.090	0.100	5581
04/18/02	0.000	0.000	0.005	1351
04/18/02	0.000	0.000	0.440	5581
08/16/02	0.000	0.000	0.000	1351
08/16/02	0.000	0.000	0.000	5581
08/22/02	0.000	0.000	0.000	5581
09/17/02	0.000	0.000	0.000	5581

*Location of NOAA Weather Stations

311 – Atlantic City Airport

1351 – Cape May

5581 – Millville Airport

WATER QUALITY STUDIES

BACTERIOLOGICAL QUALITY

The statistical summaries for this remote shellfish growing area (sampled according to APC sampling strategy) are listed in Table 8. This shellfish growing area is composed of one assignment area, Assignment 376, the Delaware Bay Offshore remote area (Cross Ledge, Deadmans & Brandywine Shoal) It is sampled using remote APC sampling strategy year-round. Figure 7 shows all of the sampling stations for this area. The raw data listings for each sampling station in accordance with the National Shellfish Sanitation Program (NSSP) criteria are given in the Appendix. There were no stations that exceeded the NSSP criteria applicable to the classification of these waters (see Table 2 for the criteria applied) (USPHS, 1999 Revision).

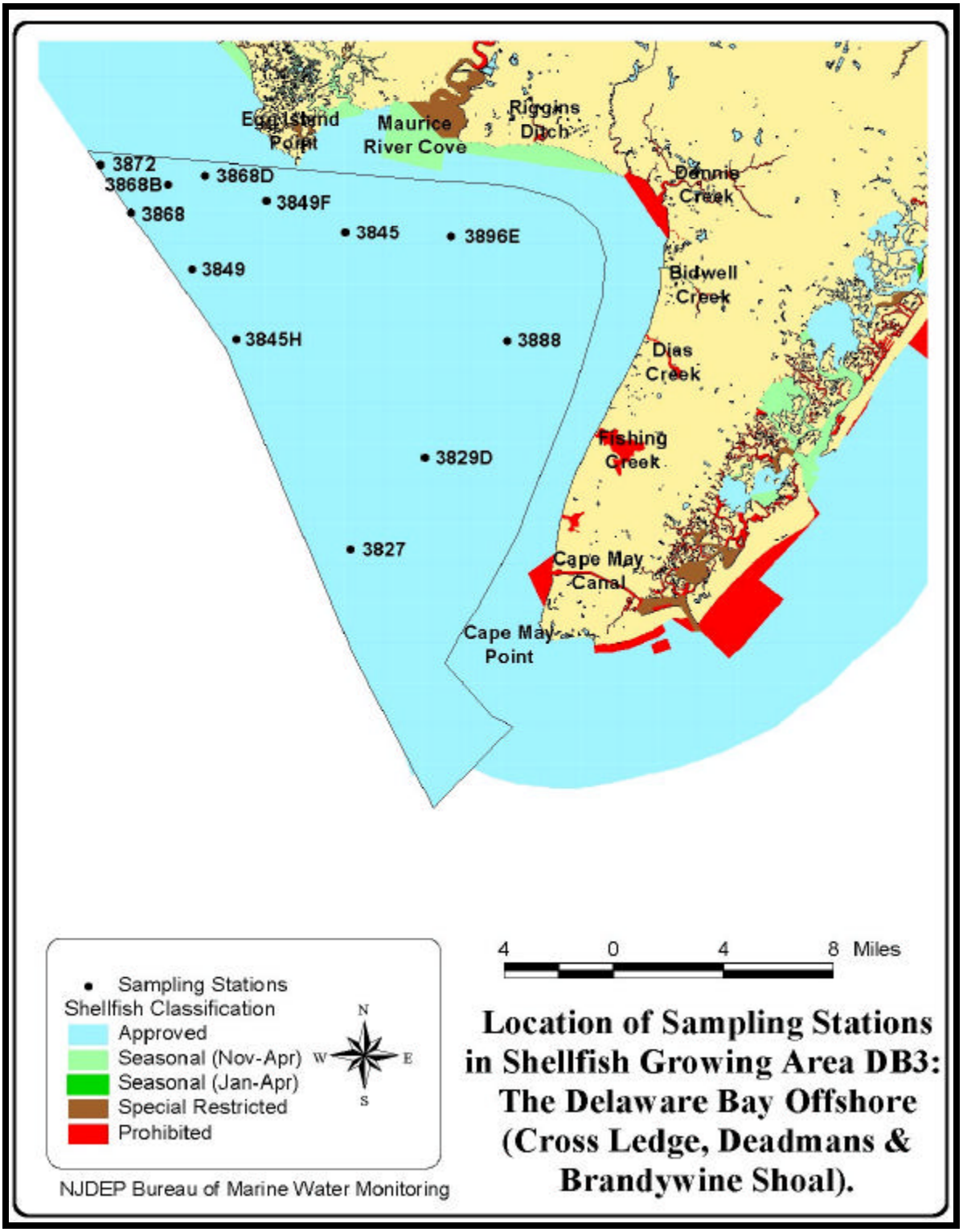

FIGURE 7: SAMPLING STATIONS FOR SHELLFISH GROWING AREA DB3 – DELAWARE BAY (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

TABLE 8 : WATER QUALITY SUMMARY (10/01/1998 – 9/30/2002)

Station	Status	Depth	Year Round			Summer			Winter		
			Geo. Mean	%>330	N	Geo. Mean	%>330	N	Geo. Mean	%>330	N
3827	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3829D	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3845	A	Surface	3.4	0.0%	15	3.5	0.0%	12	3.0	0.0%	3
3845H	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3849	A	Surface	3.1	0.0%	15	3.1	0.0%	12	3.0	0.0%	3
3849F	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3868	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3868B	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3868D	A	Surface	3.1	0.0%	15	3.1	0.0%	12	3.0	0.0%	3
3872	A	Surface	4.5	3.7%	27	5.9	6.3%	16	3.1	0.0%	11
3888	A	Surface	3.0	0.0%	15	3.0	0.0%	12	3.0	0.0%	3
3896E	A	Surface	4.0	0.0%	15	4.0	0.0%	12	4.3	0.0%	3

RAINFALL EFFECTS

Non-point source pressures on shellfish beds in New Jersey originate in materials that enter the water via stormwater. These materials include bacteria, as well as other waste that enters the stormwater collection system.

Data comparing the difference between coliform levels measured after rainfall with those during dry periods from 1998 to 2002 for this shellfish growing area were compared to generate the table and map below (see Table 9 and Figure 8. Rainfall impacts were assessed by correlating total coliform MPN values with cumulative rainfall on the day of sampling, 24 hours prior to the day of sampling, and 48 hours prior to the day of sampling. A relationship between rainfall amounts and total coliform levels is suggested if the rainfall correlation coefficient is greater than 0.6.

The Bureau of Marine Water Monitoring has begun to identify particular stormwater outfalls that discharge excessive bacteriological loads during

storm events. In some cases, specific discharge points can be identified. When specific outfalls are identified as significant sources, the Department works with the county and municipality to further refine the source(s) of the contamination and implement remediation activities.

It should be noted that a particular short-term data set might not indicate significant rainfall effects even if the historical data indicate that a significant effect occurs in a particular area. This is due to one or more of the following factors:

- Data during the short term may consist of primarily rainfall data or dry weather data. In this case, if there are insufficient data points in each category, the test for significance can not be done.
- Data collected after rainfall in the normal sampling regime may miss the effects of the 'first flush'.
- Rainfall data are based on the closest established NOAA station. Since rainfall patterns along the coastline, particularly during the summer months, tend to include locally heavy rainfall, the rainfall amounts recorded at the NOAA station may not accurately reflect the rainfall at the sampling station(s).

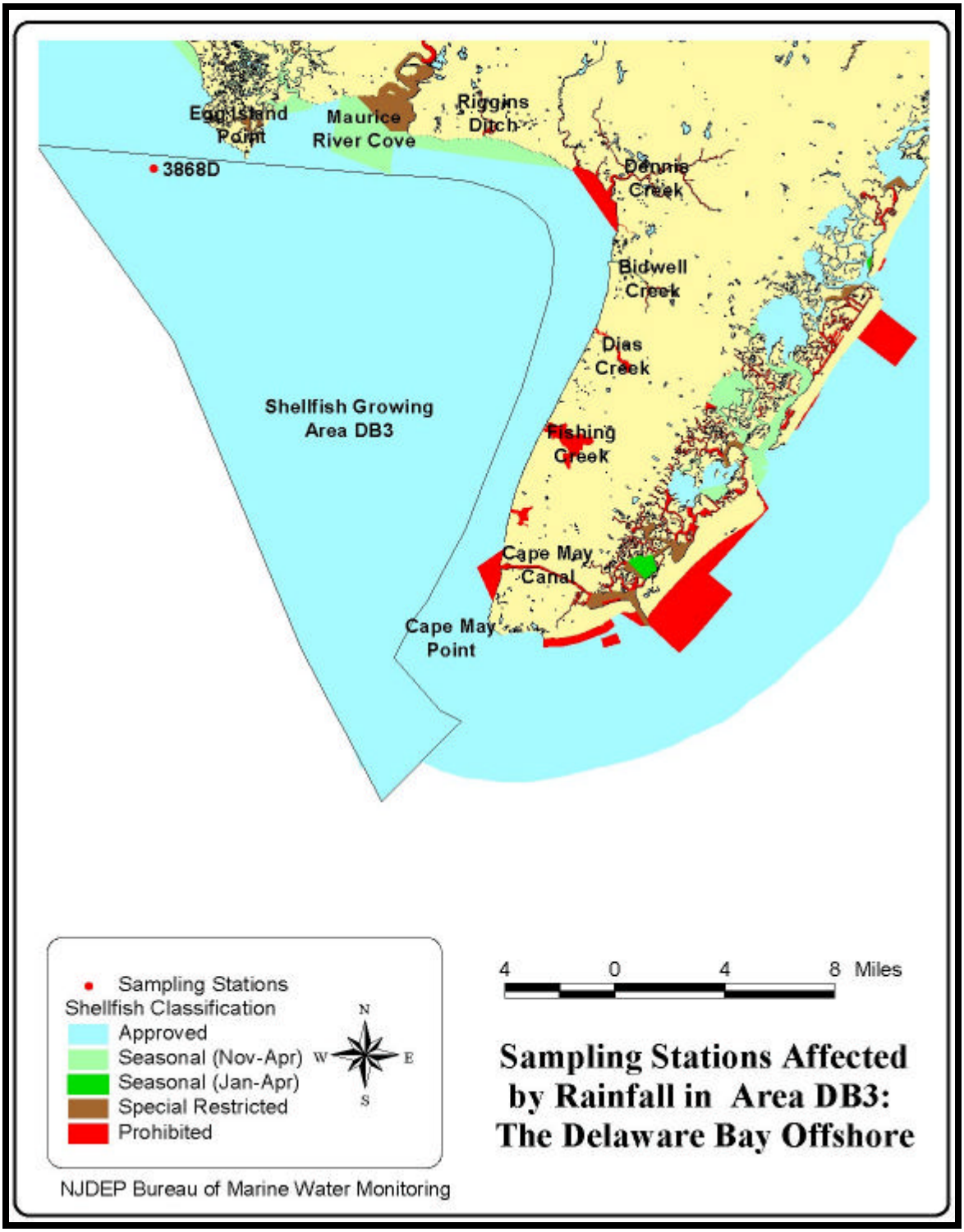

FIGURE 8: SAMPLING STATIONS AFFECTED BY RAINFALL IN SHELLFISH GROWING AREA DB3 – DELAWARE BAY (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

TABLE 9: CORRELATION OF TOTAL COLIFORM VALUES WITH CUMULATIVE RAINFALL

Station	Correlation of Total coliform with rainfall			Number of Observations
	Day of Sampling	24 hours prior	48 hours prior	
3868D	0.673	0.568	0.071	15

INTERPETATION AND DISCUSSION OF DATA

BACTERIOLOGICAL

Criteria for bacterial acceptability of shellfish growing waters are provided in the National Shellfish Sanitation Program *Guide for the Control of Molluscan Shellfish* (USPHS, 1999 Revision). Each state must adopt either the total coliform criteria or fecal coliform criteria for growing water classifications. Historically, New Jersey has based growing water classifications on the total coliform criteria and continues to use the total coliform criteria.

While New Jersey does make corresponding fecal determinations for each total coliform determination, these data are viewed as adjunct information and is not directly used for classification. Therefore, the data analysis is based on the total coliform results in which the total coliform median or geometric mean MPN (most probable number) for the ***Approved*** classification shall not exceed 70/100mL, and not more than 10% of the sample shall exceed an MPN of 330/100mL, where the three tube decimal test is used for **Adverse Pollution Condition (APC)** strategy (see Table 2) (USPHS, 1999 Revision).

In remote Shellfish Growing Area DB3 - The Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) water quality data was evaluated using the Adverse Pollution Condition (APC) strategy. According to the NSSP remote area sampling criteria, this sampling strategy requires a minimum of 2 runs per year for each sampling station. From October 1998 to September 2002, 5 runs per year were collected for each sampling station.

Figure 9 shows the sampling stations that meet the *Approved* criteria for water quality after being sampled with the Adverse Pollution Condition (APC) remote strategy. All of the sampling stations in this shellfish growing area meet the *Approved* criteria for water quality.

A significant correlation between total coliform MPN and rainfall was found to occur at one of the 12 sampling stations in this shellfish growing area (see Figure

8 and Table 9). Sampling station **3868D** is located southwest of the coast of Egg Island Point, in *Approved* waters. This sampling station showed a rainfall correlation on the day of sampling, with a level of 0.673. There was no rainfall correlation 24 hours prior to the day of sampling or 48 hours prior to the day of sampling. Rainfall impacts were assessed by correlating total coliform MPN values with cumulative rainfall on the day of sampling, 24 hours prior to the day of sampling, and 48 hours prior to the day of sampling. A correlation between rainfall amounts and total coliform levels exists if the rainfall correlation levels are greater than 0.6. In the September 1998 Reappraisal of Shellfish Growing Area DB-3, there were no sampling stations that showed a rainfall correlation to water quality.

There were no sampling stations that showed a seasonal or tidal correlation to water quality in this remote offshore shellfish growing area. Seasonal effects are assessed using a t-test to compare log- transformed total coliform values for summer verses winter data. Tidal impacts were evaluated by performing a t-test on log- transformed total coliform MPN values.

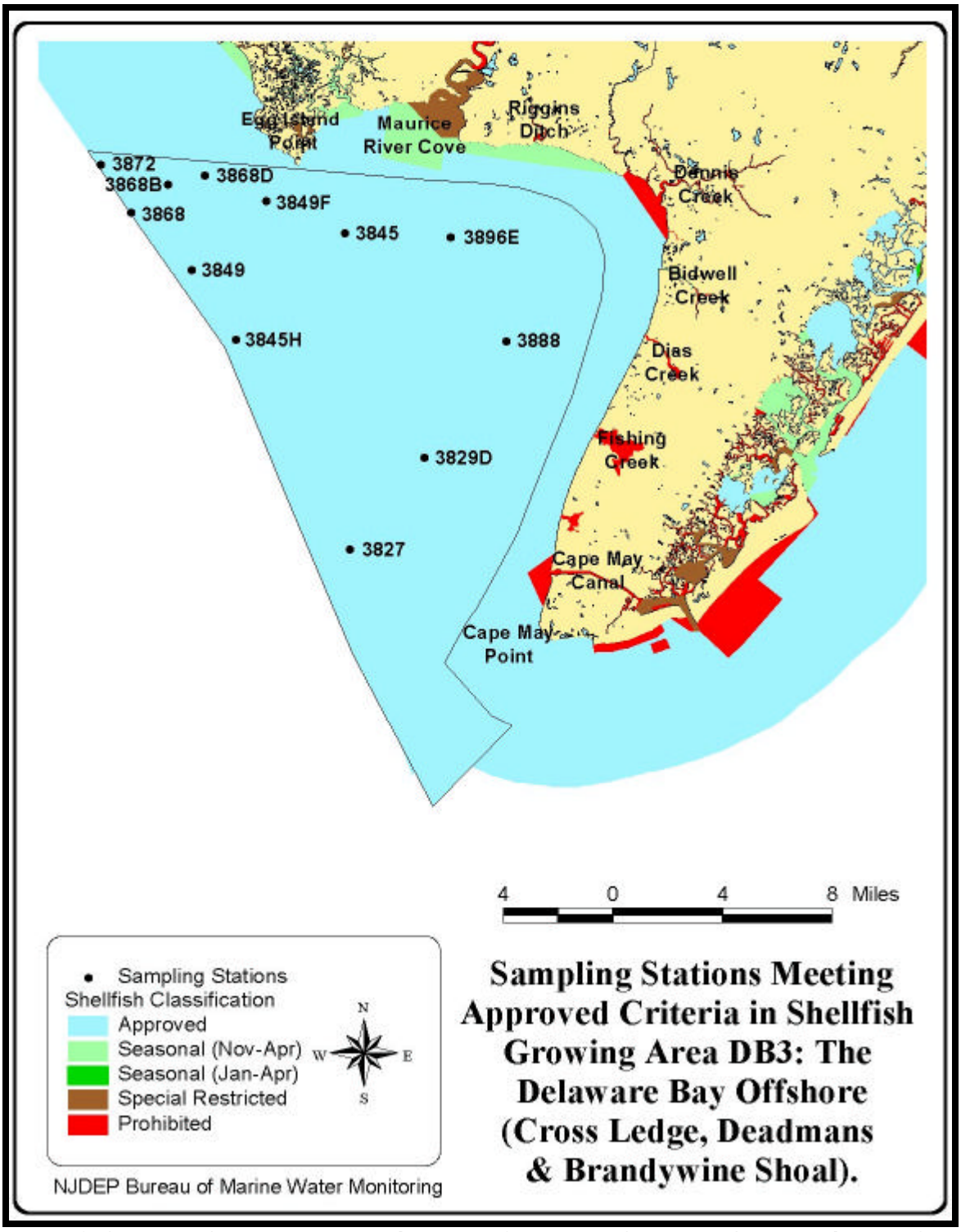

FIGURE 9: SAMPLING STATIONS MEETING APPROVED CRITERIA IN SHELLFISH GROWING AREA DB3 – DELAWARE BAY (CROSS LEDGE, DEADMANS & BRANDYWINE SHOAL).

RELATED STUDIES

NUTRIENTS

According to the 2002-2003 Marine Water Sampling Assignments Schedule for Assignment 376, The Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal), there are six stations in Shellfish Growing Area DB3 that are sampled under the estuarine monitoring program for chemical parameters including nutrients. These nutrient stations include sampling stations **3827**, **3849B**, **3868**, **3888**, **3900A**, and **3900M**. However, nutrient stations **3900A** and **3900M** are actually located in the Maurice River in Shellfish Growing Area DB1 in Assignment 327, Money Island to East Point. This report only includes the four nutrient stations (**3827**, **3849B**, **3868**, and **3888)** that are actually located in Shellfish Growing Area DB3. Two of these nutrient stations are located in the northwest part of this remote shellfish growing area, one of these nutrient station is located in the east part of this remote shellfish growing area, and one nutrient station is located in the southwest part of this remote shellfish growing area (see Figure 10).

At these nutrient stations, the various parameters measured include water temperature (in Celsius), salinity levels, Secchi Depth, total suspended solids, dissolved oxygen levels, ammonia levels, nitrate and nitrite levels, orthophosphate levels, total nitrogen levels, and the inorganic nitrogen to phosphorus ratios (Zimmer, 2000, Zimmer, 2001).

Water quality at the four nutrient stations in this shellfish growing area is consistent with the water results found throughout the State. More detailed information concerning dissolved oxygen and nutrient levels can be found in the Estuarine Monitoring Report published by the NJDEP. The latest report (New Jersey Ambient Monitoring Program: Report on Marine and Coastal Water Quality - 2000) is available from the Bureau of Marine Water Monitoring (Zimmer, 2001).

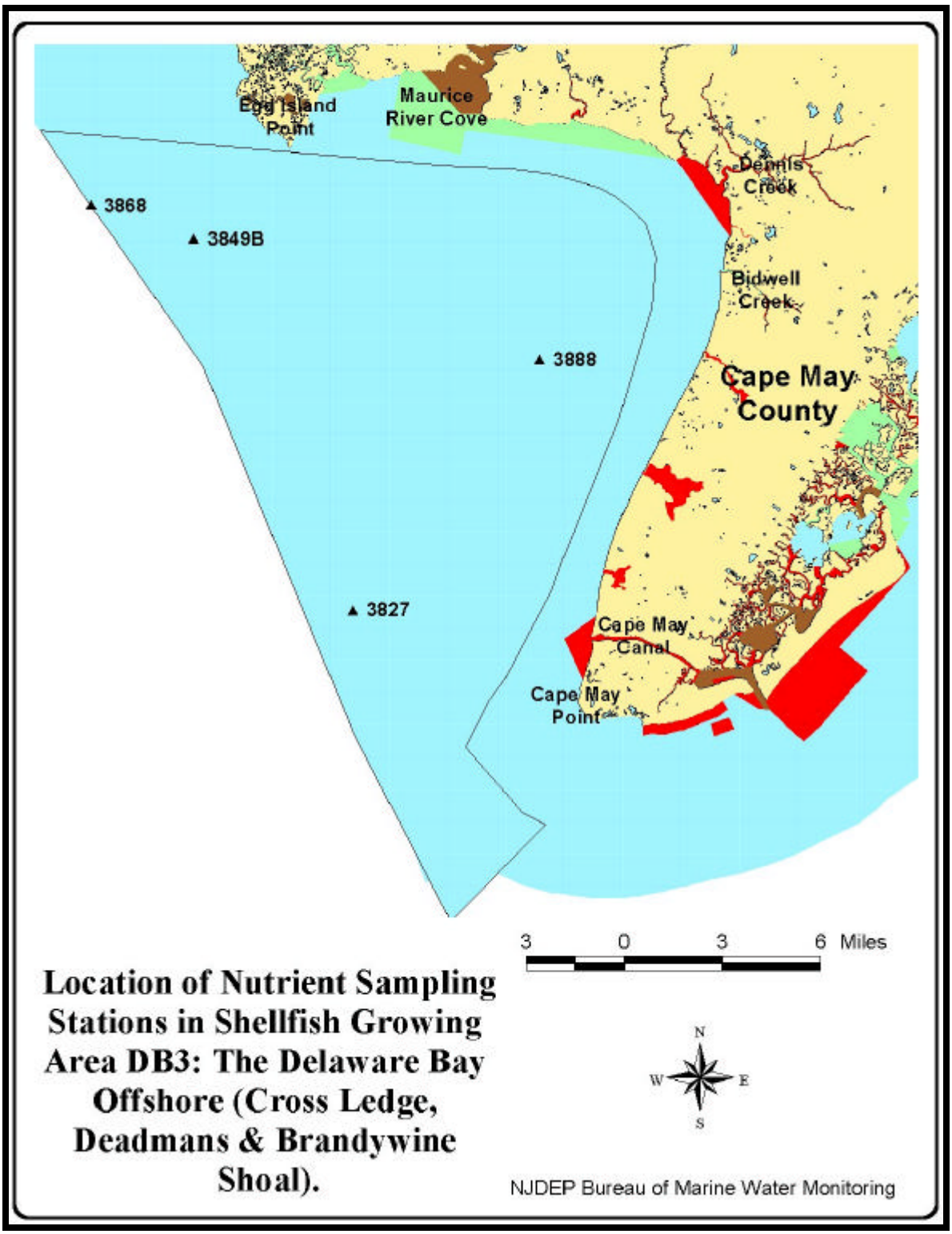

FIGURE 10: SAMPLING SITES WHERE ADDITIONAL DATA HAVE BEEN COLLECTED FOR NUTRIENTS

MARINE BIOTOXINS

The Department collects samples at regular intervals throughout the summer to determine the occurrence of marine algae that produce biotoxins (see Figure 11 for location of Phytoplankton sampling stations). Certain planktonic species have the potential to adversely affect the suitability of shellfish for human consumption. These planktonic species cause algal blooms that deplete the dissolved oxygen levels in the water. Algal blooms were reported each year for the period 1993 – 1997. The areas most severely impacted include the Raritan / Sandy Hook Bay, the Barnegat Bay, and sporadic offshore areas (NJDEP, 2001, Zimmer, 2000, Zimmer, 2001). No algal blooms capable of producing biotoxins were identified for this area during 1998, 1999, 2000, or 2001 (NJDEP, 2001). These data are evaluated weekly by the Bureau of Marine Water Monitoring in accordance with the NSSP requirements. An annual report is compiled and is available electronically at:

www.state.nj.us/dep/wmm/bmw.

FIGURE 11: LOCATION OF PHYTOPLANKTON SAMPLING STATIONS.

CONCLUSIONS

BACTERIOLOGICAL EVALUATION

Water quality in remote Shellfish Growing Area DB3 - The Delaware Bay Offshore (Cross Ledge, Deadmans & Brandywine Shoal) continues to be good, with all of the sampling stations in compliance with the shellfish classification for this area, based on NSSP total coliform criteria.

Shellfish Growing Area DB3 is correctly classified as *Approved.* No classification change is recommended for this remote shellfish growing area at this time.

RECOMMENDATIONS

BACTERIOLOGICAL EVALUATION

RECOMMENDED CHANGES IN MONITORING SCHEDULE

Continue sampling using the existing remote year-round strategy for Assignment 376. Since only 2 runs per year are recommended by NSSP criteria for remote shellfish growing areas, reduce the number of runs collected per year from 5 to 2 for Assignment 376 (Delaware Bay - Cross Ledge, Deadmans & Brandywine Shoal).

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APPENDICES

A. Statistical Summaries

- Year-Round
- Winter Only
- Summer Only

B. Seasonal Evaluation

C. Precipitation

- Rainfall Correlation
- Cumulative Rainfall
- Wet Weather Statistical Summary
- Dry Weather Statistical Summary

D. Tidal Evaluation

E. Data Listing - 1998 through 2002